# 7. REMEDIAL ACTION OBJECTIVES AND ASSEMBLY OF REMEDIATION ALTERNATIVES

This chapter presents the following Feasibility Study (FS) elements:

- **Development of remedial action objectives.** Objectives and cleanup levels are established that provide the basis for developing and evaluating alternatives for remediation of the site.

- **Identification and screening of remediation technologies.** Candidate technologies are screened on a site-specific basis to obtain a list of technologies feasible for use in assembling remediation alternatives.

- **Identification and screening of remediation alternatives.** Remediation technologies are assembled into a wide range of alternatives for remedial action at the site. The alternatives are then screened to obtain a focused list of potentially feasible alternatives for further consideration.

These components are presented in the following sections. The detailed development and evaluation of retained alternatives is presented in Chapter 8 and 9. Together these three chapters provide a complete FS for this site.

## 7.1 Development Of Remedial Action Objectives

Remedial action objectives (RAOs) are site-specific goals based on acceptable exposure levels that are protective of human health and the environment and consider applicable or relevant and appropriate requirements (ARARs). RAOs combine consideration of applicable or relevant and appropriate requirements (ARARs) and the specific constituents, affected media, and potential exposure pathways of the site. Remedial action objectives identify risk pathways that remedial actions should address, and identify site-specific acceptable exposure concentrations consistent with applicable regulations.

### 7.1.1 Remedial Action Objectives

As discussed in Section 6.5, the only identified constituents of concern found at the site as a result of past site activities were found at relatively low concentrations in surficial soil in the northern portion of the trench. Soils outside the northern portion of the trench, groundwater and surface water are not affected by the Landsburg Mine site.

Considering the information collected in the RI, the potential risk of identified constituents of concern, and potential migration pathways of materials disposed at the site, the remedial action objectives for this site are:

- Minimize the potential for future direct exposure of human or ecological receptors to any waste constituents that may remain at the site.

- Reduce the potential for migration of any waste constituents from the trench in groundwater, surface water, or airborne dust.

### 7.1.2 Preliminary Remediation Goals

Preliminary remediation goals (PRGs) are numeric expressions of remedial action objectives. A remediation goal is the maximum acceptable concentration of a constituent of concern to which the human or ecological receptors would be exposed via a specified exposure route (e.g., direct contact) under a specified exposure scenario (e.g., industrial land use). Remediation goals are generally established for constituents of concern as the lower of a numeric chemical-specific ARAR or a risk-based cleanup concentration. Remediation goals are presented as preliminary in the FS because the final remediation goals, or cleanup levels, are set in the Cleanup Action Plan (CAP).

Only a few constituents of potential concern due to disposal activities at the site were identified in the trench, and none in area surface or ground waters. Because of the variety of wastes that have reportedly been disposed in the Landsburg Mine trench, identified constituents of concern for the trench cannot be taken as representative of other wastes which may be buried in the trench. Additional constituents of concern could be encountered either during site excavation or in the event groundwater were to become affected. Therefore, it would have little meaning to establish remediation goals (cleanup levels) based on the few identified constituents of concern. In addition, setting PRGs for specific constituents is not necessary for remedies not involving removal of affected media (i.e., capping).

Nevertheless, the general framework which would be used to determine remediation goals for any identified constituents of concern can be established. Under MTCA, acceptable exposure levels for carcinogens are concentration levels that represent potential lifetime incremental cancer risk to an individual of $10^{-6}$ for individual constituents in a residential exposure scenario, $10^{-5}$ for individual constituents in an industrial exposure scenario, and $10^{-5}$ for combined constituent risks in both scenarios. For non-carcinogens, acceptable exposures levels are concentrations that correspond to a hazard index less than 1.0. In addition, as discussed in Section 4, MCLs are relevant and appropriate to this site.

Remediation goals for remedial action involving excavation are set as the MTCA Method B concentrations for site constituents of concern detected in excavated soil. Remediation goals for groundwater, for purposes of monitoring or groundwater removal, are set as the MCLs for site constituents of concern. Remediation goals are only applicable to constituents of concern that result from waste disposal activities at the Landsburg Mine site. As discussed in Section 6.5, remediation goals are not applicable, relevant, or appropriate for other constituents because they are present due to natural site conditions.

## 7.2 Identification And Screening Of Technologies

This section identifies and screens technologies that may be included as part of remediation alternatives for the Landsburg Mine site. A comprehensive list of technologies and process options that are potentially applicable to this site is developed to cover all the applicable general response actions. The list of technologies are then screened to develop a refined list of potentially feasible technologies that can then be used to develop remediation alternatives for the site. The remediation technologies are screened using the following criteria:

> **Effectiveness -** The potential effectiveness of the technology to (1) address site-specific conditions, including applicability to the media and constituents of concern for this site, (2) meet remedial action objectives, (3) minimize human health and environmental impacts during implementation, and (4) provide proven and reliable remediation under site conditions.
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> **Implementability -** The technical and administrative feasibility of implementing a technology. Technical considerations cover site-specific factors that could prevent successful use of a technology, such as physical interferences or constraints, practical limitations of a technology, and soil properties. Administrative considerations include the ability to obtain permits and the availability of qualified contractors, equipment, and disposal services.
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> **Cost -** The capital and operation and maintenance costs associated with the technology. Costs that are excessive compared to the overall effectiveness of the technology may be considered as one of several factors used to eliminate technologies. Technologies providing effectiveness and implementability similar to that of another technology by employing a similar method of treatment or engineering control, but at greater cost, may be eliminated. At the screening level, the cost evaluation is based on engineering judgment of relative costs.

The technologies and process options are screened against the criteria in the priority order listed above using the "fatal flaw" approach. This approach ranks the criteria in order of importance, as listed above. Once a technology is rejected based on effectiveness, it is not further evaluated based on implementability or cost. Similarly, if a technology is effective, but not implementable, the technology is rejected and evaluation of cost is not undertaken. This approach streamlines the evaluation of technologies while maintaining the MTCA screening methodology.

Evaluation and screening of technologies are performed in a single step. The key criterion in selecting the screening level (technology class, individual technology, or process option) is whether there is a significant difference between the technologies or process options when evaluated against the screening criteria (effectiveness, implementability, and cost). Technologies and process options that are judged to have significant differences are screened separately, and the retained technologies or process options will be developed into separate remediation alternatives to allow full evaluation and comparison.

Process options retained for any given technology that are screened together (i.e., not evaluated separately) are considered equally suitable (at the screening level of evaluation). Selection of representative process options is performed during the development of alternatives, so that best engineering judgment may be used to select and combine appropriate technologies and process options into cohesive, integrated remediation alternatives.

The potentially applicable technologies considered for the Landsburg Mine site are presented in Table 7-1. The technology screening is also summarized in this table. Brief descriptions of the listed technologies and discussions of the screening evaluations are provided below. Technologies retained through this screening process are then incorporated into remediation alternatives in Section 7.3.

### 7.2.1 General Response Actions

General response actions are broad categories of remedial actions that can be combined to meet remedial actions at a site. The following general response actions are generally applicable to most sites, including the Landsburg Mine site:

- No action
- Institutional controls (including monitoring)
- Containment
- Removal
- Ex-Situ Treatment (including reuse and recycling)
- In-Situ Treatment
- Disposal

Except for "no action," each of these response actions represents a category of technologies. The applicable technologies will vary depending on the media (e.g., soil or groundwater) and constituents of concern (e.g., organic compounds or metals). The discussion of technologies is organized below by general response actions for soil and groundwater (the applicable media).

### 7.2.2 Institutional Controls And Monitoring

Institutional controls are legal and physical restrictions to exposure to constituents of concern at the site. Risk is eliminated by institutional controls to the extent that they prevent exposure to affected media. However, institutional controls do not prevent off-site transport of constituents. Institutional controls include any maintenance required for ongoing effectiveness. Institutional controls are effective within their limitations, are easily implemented, and are low in cost. Institutional controls are typically included in any remedy where constituents of concern will remain after completion of remediation.

**Site Access Restrictions**. Access restrictions involve preventing access by unauthorized persons. Fencing, combined with warning signs, is the most common means of restricting access. Security patrols are sometimes included for high-risk areas, but would not be warranted for this site. Fencing provides a physical barrier to site access. Warning signs discourage trespass by warning potential intruders of the hazards of entering the area. Fencing and warning signs are retained for further consideration.

**Land Use Restrictions**. Land use restrictions are legal controls such as deed restrictions that guide development or activities at the site. Deed restrictions are notices of land use restrictions that accompany the deed to the property in a manner that is legally binding and must be transferred to all subsequent owners of the property. The restrictions would include a description of the site and reasons for the limits on future activity. Such restrictions would prevent activities or development that would cause direct exposure to constituents of concern, or that would compromise the integrity of the remedy. For example, deed restrictions could prohibit site development that could impair the effectiveness of a cap remedy. The site is currently considered a Coal Mine Hazard under the King County Sensitive Areas ordinance, which affects development activities. Land use restrictions are retained for further consideration.

**Groundwater Use Restrictions**. Withdrawal or use of site groundwater can be restricted by legal controls. These controls can eliminate or minimize risk due to exposure to groundwater affected by constituents of concern. For this site, there is no identified affected groundwater. However, groundwater use restrictions could be combined with monitoring to prevent exposure in the event that site groundwater were to become affected by waste constituents. Groundwater use restrictions are retained for further consideration.

**Alternate Water Supply**. Where constituents of concern are impacting an existing drinking water supply, an alternate source of drinking water may be supplied. Drinking water supplies are not currently impacted by the Landsburg Mine site. However, as discussed in Section 6.6, there is a slight possibility that local water supply wells could become affected in the future by site waste constituents. Provision of an alternate water supply would be a rapid, easily implemented means of responding to a groundwater problem, and is therefore retained for further consideration.

**Monitoring.** Site monitoring is a required component of any site remedy (including "no action"). Short-term monitoring is conducted to ensure that potential risks to human health and the environment are controlled while a site remedy is being implemented. Long-term monitoring is conducted to measure the effectiveness of the remedy and thereby ensure that the remedy continues to be protective of human health and the environment. Long-term monitoring would include periodic site inspections as necessary to determine maintenance needs (e.g., for fencing or a cap). A monitoring plan will be developed for the selected remedial action. The type of monitoring performed will depend on the nature of the remedy. Monitoring could include periodic sampling and analysis of air, surface water, and groundwater, as appropriate.

### 7.2.3 Containment

In-situ containment is a general response action used to prevent exposure to material affected by constituents of concern that are left in place, and to control migration of constituents. Containment technologies are identified and screened in this section.

#### 7.2.3.1 Trench Backfill

The site contains a trench that, due to its depressed elevation, collects surface water drainage. The collected surface water then infiltrates into the groundwater, increasing the local groundwater flow rate and the potential for migration of any constituents of concern in the subsurface. Backfilling the trench in the area of waste disposal would prevent direct contact with any constituents of concern in the trench. The backfill would provide a thick physical barrier that would greatly enhance the effectiveness and reliability of a cap or other containment remedy. The backfill, even without a cap, would also prevent off-site migration of constituents of concern in airborne dust or surface water. By significantly reducing infiltration of stormwater run-on currently collected in the trench, backfilling would also greatly decrease the potential for groundwater becoming affected by any constituents of concern. In addition, filling the trench in the area of waste disposal would make stormwater management easier for capping. Trench backfill would be restricted to the area of former waste disposal.

The trench also presents physical hazards which are the result of historic coal mining activities and are not the result of waste disposal activities. Backfilling the trench as part of environmental remediation would result in incidental reduction of these hazards. However, the scope of MTCA and remediation at this site is limited to environmental effects of waste disposal activities. Therefore, removal of physical trench hazards is not a remedial action goal at this site. Hazards resulting from historic mining activities fall under the jurisdiction of the Office of Surface Mining (OSM) of the U.S. Department of the Interior. The OSM has a program for addressing mine subsidence such as the Landsburg Mine trench under the Abandoned Mine Reclamation Fund. Coal lands are eligible for reclamation under this program if they were mined prior to August 3, 1977, were subsequently abandoned, and are in need of partial or complete reclamation. Therefore, trench backfilling or other methods of addressing any physical hazards at this site due to mining hazards would need to be addressed under the OSM Abandoned Mine Reclamation Fund program.

Suitable fill material would include any inert material capable of bearing overlying loads without undo settlement. Such materials could include, but are not limited to, coal refuse, shale, sandstone, broken concrete, and soils. The trench would not require backfilling to current grade, so long as good stormwater drainage is provided. This could be achieved by a combination of cut and fill to achieve the desired grading, and by other stormwater controls discussed in Section 7.2.3.4. Topography after trench backfill, cut-and-fill, grading, and stormwater drainage are addressed in the detailed development of alternatives (Chapter 8). Backfilling the trench is retained for further consideration.

#### 7.2.3.2 Capping

Capping is proven, effective technology for providing reliable long-term containment and preventing or minimizing off-site migration of constituents. Capping minimizes risk by preventing direct contact with waste and affected soil, and preventing off-site migration of constituents in surface water or airborne dust. Where infiltration through waste or affected soil is a concern, a low-permeability cap design is used to minimize the potential for constituent migration into groundwater by minimizing infiltration of precipitation.

Caps may be constructed of a variety of natural materials (i.e., clay, sand, and other soils), synthetic liners, geotextiles, and other geomembranes, and other synthetic materials (e.g., asphalt or concrete). They may consist of a single layer or be a composite of several layers. Caps provide containment in three primary ways:

- A cap serves as a physical barrier to prevent humans, other animals, and vegetation from coming in contact with materials affected by constituents of concern.

- A cap prevents erosion of soil by surface water and wind, thereby preventing off-site transport of constituents of concern via these media.

- A low-permeability cap contributes to run-on and run-off control and minimizes infiltration of surface water, decreasing the potential for transport of constituents of concern from waste or affected soil to groundwater.

Caps can be designed to be compatible with many potential future site uses. Land use restrictions and other institutional controls are typically employed along with capping to prevent future site activities that could violate the integrity of the cap (e.g., excavation or support pilings for buildings). Long-term maintenance and monitoring are required.

Capping is readily implemented using standard design and construction techniques. It is relatively low cost, and thus highly cost-effective (i.e., high incremental protection relative to remediation cost). A wide variety of cap designs are possible that vary in effectiveness, implementability and cost. The following representative cap designs have been identified and screened for consideration:

- Soil
- Paving
- Low-permeability clay with vegetative soil cover
- Synthetic membrane with vegetative soil cover
- Combined synthetic membrane and bentonite liners with vegetated soil cover
- RCRA Subtitle C design

These designs are illustrated in Figure 7-1 and discussed below.

**Soil Cap.** As shown in Figure 7-1(a), a soil cap would consist of a minimum of 18 inches of clean soil fill overlain by 6 inches of vegetated topsoil. The soil cover would augment the containment provided by trench backfill, and provide additional evapotranspiration to decrease infiltration. A soil cover would be just as effective as low-permeability cap designs at preventing direct contact and off-site migration of constituents in surface water or airborne dust. While not as effective as a low-permeability design at minimizing infiltration, most of the decrease in infiltration (for any cap design) compared to current conditions ("no action") would be provided by the combined effects of trench backfill preventing stormwater run-on and the evapotranspiration provided by the soil cap. A soil cap would be easier to construct and less costly. Because of possible mine subsidence and trench settlement, it would be easier to maintain. This cap design is retained for further consideration.

**Paving.** Asphalt and/or concrete pavement is suitable for providing a cap for some sites. However, paving as a cap is generally considered for developed areas where there is a need to combine containment with continued commercial or industrial use (e.g., as a parking lot). Paving requires higher maintenance than caps with soil or synthetic liners, and is prone to cracking. Trench settlement would increase maintenance costs. Paving would increase stormwater run-off velocities, which at this site (given its topography) could enhance erosion of surrounding areas. Paving is therefore not retained as a cap design.

**Low-Permeability Soil Cap.** As shown in Figure 7-1(b), a low-permeability soil cap would consist of a liner of 2 feet of compacted low-permeability soil, overlain by 6 inches of vegetated topsoil. The cap would be designed to meet MFS (WAC 173-304). By providing a low-permeability liner in addition to stormwater diversion, this cap design would decrease infiltration through the disposal area and thereby decrease the potential for groundwater becoming affected by constituents of concern. A soil liner would be easier to repair in the event of settlement than a synthetic liner. This cap design is therefore retained for further consideration.

**FML Cap.** As shown in Figure 7-1(c), a FML Cap would consist of a synthetic flexible membrane liner (FML) under 6 inches of clean fill soil and 6 inches of vegetated topsoil. The cap would be designed to meet MFS (WAC 173-304). As with the low-permeability soil cap, a FML cap would provide additional protection against the potential for groundwater to become affected by constituents of concern. The FML, properly installed and maintained, is less permeable than a low-permeability soil liner. However, FML is susceptible to failure with settlement. A low-permeability soil cap could be more reliable because soil tends to be self-sealing, and would also be somewhat easier to maintain. Both are readily constructed using standard methods and contractors routinely employed for landfills. This cap design is retained for further consideration.

**FML/GCL Cap.** As shown in figure 7-1(d), the composite FML/GCL cap would consist of 2 liners: a FML and a geosynthetic clay liner (GCL). The GCL is essentially very low permeability clay (bentonite) between geotextile layers. The liners would be covered by 6 inches of clean fill soil and 6 inches of vegetated topsoil. Because of the redundant liners, the FML would not need to be as thick as in the FML cap. The FML/GCL cap would exceed MFS (WAC 173-304). By providing redundant liners, this cap would be more reliable and therefore somewhat more protective than the FML or low-permeability soil cap designs described above. However, the liners are susceptible to failure with settlement. Having two liners would increase the difficulty in installation and the cost of the cap over a single-liner design. The FML/GCL cap design is included to allow consideration of the marginal benefit of conservative cap design, and is retained for further consideration.

**RCRA Subtitle C Cap.** Design standards for hazardous waste landfills under RCRA (40 CFR 264) provide the most conservative cap design. This composite cap type provides combined low-permeability soil and synthetic liners (similar to the FML/GCL cap), specifies lower permeability soil ($10^{-7}$ cm/sec instead of $10^{-6}$ cm/sec), and adds a drainage layer above the liners to route infiltration from the vegetative layer away from the liner. This complex design, although implementable, would be significantly more difficult to install and much more expensive than the other designs. The design permeability of a RCRA cap would not be less than the FML or FML/GCL caps, and would not reduce infiltration significantly compared to the low-permeability soil cap. The RCRA cap is designed to provide additional protection by adding reliability, in the form of redundant protection against infiltration. However, at this site, a RCRA cap would be susceptible to failure with settlement. Given the limited potential risk at this site, the lower implementability, and greater cost, the marginal added benefit is not justified. This cap design is therefore not retained.

7.2.3.3 Dust Control

Dust control incorporates any measures to prevent wind dispersion of soil affected by constituents of concern. Several approaches to dust control are available. Water is the most common method of short-term dust control. For long-term dust control, vegetation can be planted to hold the soil together and reduce wind velocity at the ground surface. Migration of site constituents via dust is not a problem at this site. However, excavation of the trench could generate dust from affected soil; therefore, dust controls are retained for possible use in conjunction with excavation.

7.2.3.4 Surface Water Controls

Surface water management involves controlling surface water run-on and run-off at the site. The purpose of these controls is to minimize erosion that can entrain exposed soil affected by constituents of concern, and expose underlying affected materials. Surface water controls by themselves are not generally effective as a permanent remedy. These controls may be used as short-term measures (e.g., during excavation), or as long-term measures (e.g., as part of capping). Surface water controls are proven technology, effective, easily implemented and inexpensive. They are therefore retained for use in conjunction with other remediation technologies.

**Grading**. Grading is used to promote stormwater drainage, which reduces infiltration through a cap, while minimizing erosion. At the trench, grading would also prevent or minimize stormwater run-on, thereby decreasing infiltration through the trench.

**Stormwater Drainage Controls**. In addition to grading, stormwater drainage can be controlled by berms and ditches or swales. Ditches and swales are channels designed to collect stormwater and route it to a desired discharge point. They may be unlined or, to reduce erosion, lined with gravel, concrete, synthetic membranes, or other materials. Piping can also be used to route collected stormwater to the desired discharge point. Retention basins can be used to slow flow velocities and trap sediment, thereby decreasing erosion potential.

**Vegetative Cover.** Vegetative cover is a common, highly effective means of reducing soil erosion. Once established, vegetation requires little or no maintenance. Vegetation also provides evapotranspiration that reduces infiltration of stormwater through a cap.

7.2.3.5 Vertical Barriers

Vertical barriers are intended to minimize lateral flow of groundwater, thereby preventing or minimizing migration of constituents of concern. For reliable containment, vertical barriers should be keyed into a continuous low-permeability stratum or an artificial horizontal barrier to prevent migration underneath the vertical barrier. Slurry walls, sheet pile walls, grout walls, and cryogenic walls are established technologies for constructing vertical barriers under appropriate site conditions.

**Slurry Walls.** Slurry walls are constructed by excavation of a vertical trench and adding admix to soil in a slurry to construct a low-permeability vertical wall. The slurry mixture is used to shore the trench to prevent collapse during construction and serves as part of the low-permeability backfill. Bentonite and cement/bentonite are common admixes. Cement admixes are used where structural strength is required in addition to low permeability.

**Grout Wall.** A vertical barrier can be constructed with grout, using grout injection, "deep soil mixing", or a combination of these methods. As with slurry walls, a grout wall must be keyed into a horizontal confining layer to provide complete containment. Grout injection involves drilling boreholes and pressure-injecting grout into the boreholes and outward into the surrounding soil. The boreholes are spaced closely enough to obtain overlapping grout zones, forming a continuous wall. Deep soil mixing uses a hollow-shaft auger to mix soil and grout. As the augers are advanced vertically, grout is injected into the soil and blended.

**Sheet Pile Wall.** Sheet pilings are interlocking steel sheets that are driven into the soil to form a wall. Sheet piling is primarily used for providing structural containment in excavations. Leaking can occur between individual sheets unless special measures are taken (such as grouting) to seal the seams. Steel piles will eventually deteriorate via corrosion.

**Cryogenic Wall.** A cryogenic wall (freeze wall) is an established technology for short-term containment during dam construction and deep excavation, where technical difficulties can make this expensive technology cost-effective. Frozen soil is substantially less permeable than unfrozen soil, forming a barrier to migration of constituents of concern. A cryogenic wall is formed by installing steel pipes using drilling techniques and circulating refrigerant to freeze the water in the surrounding soil. Freeze walls may be installed vertically or, using slant drilling, at an angle. A freeze wall can thus be used to prevent both vertical and horizontal migration. Freeze walls for long-term containment are unproven technology. Continuous operation of a cryogenic (refrigerant) unit is required to prevent the wall from melting, making it an active barrier, in contrast to more permanent and proven passive barriers. This technology is therefore not considered suitable as permanent containment.

**Screening.** The subsurface bedrock and coal would make it difficult to surround the trench with any vertical barrier. In addition, the site does not provide a continuous stratum into which a vertical barrier could be keyed. The great majority of the groundwater flow through the mine occurs along strike of the Rogers coal seam, towards the portals at the north and south ends of the mine. Groundwater flow across bedding is very small due to the layered nature of the materials and the low permeability of the bedrock strata which lay to either side of the disposal trench. Experience with inflow during mining indicates that existing side walls are at least as effective as barrier walls.

Barriers, if they were to be installed, would be placed across the coal seam at the ends of the mine where groundwater discharge occurs. However, hydraulic containment (see Section 7.2.3.7) would provide effective, more easily implemented, and less costly containment, should this become necessary in the future. Therefore, no vertical barrier technologies are retained.

#### 7.2.3.6 Horizontal Barriers

Horizontal barriers are intended to minimize the vertical migration of constituents of concern in groundwater in an aquifer, into deeper aquifers, or under vertical barriers. Grout injection and cryogenic barriers are technologies that could be used to construct horizontal barriers under appropriate site conditions.

**Grout Injection**. A horizontal grout barrier is constructed by drilling inclined or horizontal boreholes under the zone containing constituents of concern. Grout is injected into the boreholes and outward into the surrounding soil. An overlapping pattern of holes should form a continuous grout barrier under the affected zone. However, grout injection to form a low-permeability horizontal barrier is unproven technology that has not been performed at full scale. Inclined and horizontal drilling is more difficult to accomplish and control than vertical drilling, and requires specialized equipment. The continuity of the completed barrier is difficult to verify, particularly with heterogeneous materials in the subsurface.

**Cryogenic Wall.** Ground freezing (cryogenic barriers) has been proposed for constructing horizontal barriers. This is the same technology has been proposed for vertical barriers (see preceding discussion). This technology is unproven for long-term containment. The cryogenic plant is required to operate indefinitely to maintain the barrier, making it an active barrier in contrast to more permanent and proven passive barriers. This technology is therefore not considered suitable as permanent containment.

**Screening.** In general, horizontal barriers are difficult to implement. They would be very difficult or impossible to construct at this site because of the combination of near-surface bedrock and coal. Because of difficulties in construction and verification (quality control), horizontal barriers have questionable effectiveness and reliability. Given the subsurface mining performed at this site, the reliability would be even less than elsewhere. In addition, they would be ineffective at limiting potential migration through mine portals, which is the primary means of constituent transport at this site. For these reasons, no horizontal barrier technologies are retained.

#### 7.2.3.7 Hydraulic Groundwater Containment

Hydraulic containment consists of active manipulation of groundwater heads to prevent off-site migration of groundwater. The containment may be accomplished by lowering groundwater elevations so that groundwater flows into (and not out of) the zone affected by constituents of concern. Alternatively, groundwater may be intercepted at the boundary of the affected zone to prevent off-site migration. At this site, groundwater already meets remediation goals. Therefore, hydraulic containment is not necessary, and hydraulic containment technologies are not retained.

### 7.2.4 Removal

Removal is a general response action for media affected by constituents of concern prior to ex-situ treatment (on-site or off-site) or disposal. Groundwater removal would be a component of hydraulic containment (see Section 7.2.3.7). Removal can be complete (i.e., all portions of soil or groundwater with constituents above remediation goals), or partial (i.e., the highest concentrations of a constituent of concern). Removal by itself is not a complete remedial action, but must be combined with subsequent disposition of the removed media.

#### 7.2.4.1 Excavation

Removal of waste and affected soil from the trench may be technically feasible. Equipment that would be considered includes backhoes, loaders, bulldozers, clamshells, and draglines. The choice of equipment is typically made by the excavation contractor and is not normally part of design.

For a variety of reasons, excavation at this site would be difficult, expensive, and hazardous. In addition, trench excavation would have the potential to cause adverse impacts on groundwater and create risks to human health and the environment. Excavation concerns include the following:

- **Stability of the trench base**. Because the trench is likely underlain by shallow mine openings and voids, it would not be safe to complete the excavation with heavy equipment inside of the excavation. Although the current trench subgrade might support light equipment, the risk of a subgrade collapse would increase as the soils were removed. Thus the majority of the work would probably have to be performed from above. This would require large draglines which would be expensive and difficult to control.

- **Stability of the trench sidewalls.** There would be no safe, practical method to work inside of the excavation. It would be difficult to control sidewall failures or fill collapse. These types of problems would slow down the excavation operation, significantly impacting costs and schedule. A variety of methods are available to shore the sidewalls such as soldier piles (with tiebacks or internal cross-lot bracing), structural slurry walls, several different grouting techniques, and others. However, these methods are very expensive and not appropriate for this type of application. It would be less expensive and less time consuming to simply deal with the sidewall problems when and if they occur then to install a structural shoring system.

- **Rupture of buried drums.** In all likelihood, excavation would damage drums, resulting in release of their contents to the environment. Release of drummed chemicals would create exposure to site workers, and increase the potential for off-site exposure of human and ecological receptors. The potential risk includes the potential for affecting groundwater that currently meets remediation goals. Chemical release also creates the potential for fire or explosion if the materials are flammable.

- **Worker exposure.** In addition to high potential for new releases from drums, excavation exposes site workers to constituents of concern in any affected soil, or in releases due to drum rupture or spillage. Appropriate personal protection equipment would be used to lessen this risk, but the risk would still be greater than without excavation.

- **Mobilization of constituents of concern.** By disturbing any constituents of concern that are currently buried and immobile (as evidenced by groundwater data), excavation creates the potential for mobilization of constituents to air, surface water, and groundwater. Appropriate measures would be used to lessen this risk, but the risk would still be greater than without excavation.

Excavation of waste and affected soil (partial or complete) would be necessary to allow ex-situ treatment or off-site disposal. Therefore, despite the many problems and concerns associated with it, excavation is retained to allow consideration of a full range of alternatives.

#### 7.2.4.2 Groundwater Extraction

Groundwater may be removed for the purpose of treatment or containment. Extraction wells and interceptor trenches are common technologies for groundwater removal. However, groundwater at this site already meets remediation goals. Therefore, there is no need for groundwater removal or treatment, and no groundwater extraction technologies are retained.

### 7.2.5 Ex-Situ Treatment

#### 7.2.5.1 Waste and Affected Soil

This section considers a wide range of technologies for ex-situ treatment following excavation. There is no identified need for treatment of waste or affected soil at this site. Soil identified as affected by waste constituents is found only in a limited area of the trench with relatively low constituent concentrations. However, in the event that the trench is excavated, there is a possibility that waste or affected soil would be encountered that would require treatment prior to disposal. A treatability study would be necessary to determine the appropriate treatment method, should the trench be excavated and material requiring treatment be encountered. Ex-situ treatment technologies are therefore identified and screened for this eventuality.

Treatment is intended to reduce the toxicity, mobility or volume of material affected by constituents of concern. Many treatment technologies convert constituents of concern to less toxic forms. Destruction or degradation of organic compounds is possible (e.g., oxidation to carbon dioxide and water) although not always feasible or cost-effective. However, metals cannot be destroyed by treatment. Metal toxicity can be reduced via chemical conversion to a less toxic compound of the metal, and metals can be immobilized by fixation (stabilization).

**Reuse/Recycling.** MTCA identifies reuse and recycling as first priority for consideration in site remediation. However, no waste materials have been identified at this site with the potential for reuse or recycling. Reuse or recycling typically requires a relatively homogenous material; recycling processes are usually not feasible for complex mixtures of heterogeneous waste and affected soil. This technology is therefore not retained.

**Dry Soil Sieving.** Dry soil sieving is an ex-situ physical separation process that is performed without the addition of water. Soil is passed through one or more screens and separated into various size fractions. The concept behind remediation using this technology is that the concentrations of constituents of concern in soil particles often increase with decreasing particle size. In addition, large-mesh screens (e.g., a grizzly) are commonly used to remove debris and other large objects from waste and affected soil to facilitate handling. Although not as effective as physical soil washing, it is easy to implement and much less costly (generally a few dollars per ton of soil treated). When effective, it is highly cost-effective because of reduction in disposal costs. Therefore, this technology is retained for possible use in separating clean soil, debris, and affected soil in conjunction with excavation.

**Physical Soil Washing (Aqueous Physical Separation).** The term "soil washing" has been used to describe a variety of treatment processes. As used here, physical soil washing refers to soil washing for physical separation; "chemical extraction" is used to refer to processes using aqueous and non-aqueous solvents for extraction of constituents of concern. Physical soil washing is applicable to soil where the constituents of concern are concentrated in a particular size fraction. In practice, the majority of constituents of concern in soils are often associated with the silt and clay soil fractions (collectively called the fines), with coarser soil (sand and gravel) being relatively clean.

The effectiveness of physical soil washing is highly variable, depending on the constituents of concern and site-specific conditions. In addition, treatment of the washwater is necessary prior to discharge, and the fines must be dewatered for landfill disposal. Physical soil washing is also a relatively complex process and requires use of specialized contractors. Soil washing systems for site remediation are innovative and currently in various stages of development and implementation. Physical soil washing would not provide proven, reliable treatment for this site, would be difficult to implement, and would add significantly to remediation costs. This technology is therefore not retained.

**Chemical Extraction.** Chemical extraction is a generic term for treatment processes where a liquid solvent is used to extract constituents of concern from waste or affected soil. The spent solvent must then be treated or recovered and recycled. The terms "soil washing" and "solvent extraction" are sometimes used for processes included in this treatment category. Aqueous soil washing is included in this category when the purpose of the treatment is removal of constituents of concern from the soil, rather than separation of soil into affected and clean fractions as in physical soil washing. Other solvents and reagents that can be used include surfactants, liquid carbon dioxide, and triethylamine (TEA) for organic compounds; petroleum solvents for oil recovery; and acids or complexing agents for metals.

A number of chemical extraction processes, including extractive soil washing, have been attempted at bench and pilot scales with varying degrees of success. The effectiveness of chemical extraction is highly dependent on the constituents of concern and site-specific waste characteristics. Published data show large variations in effectiveness between sites. Chemical extraction at this site would have all of the problems cited for physical soil washing, but to a greater degree. It is less proven technology, more complex and difficult to implement, and more costly. This technology is therefore not retained.

**Fixation (Chemical Stabilization).** Fixation, also called chemical stabilization or simply stabilization, involves mixing soil affected by constituents of concern with binding agents to form a solid matrix that immobilizes the constituents of concern, and thereby reduces constituent mobility (leachability) and associated risk. Fixation typically uses pozzolanic agents, such as cement, fly ash, and lime. Proprietary additives are available that are claimed to improve immobilization. Fixation is a common, established technology for treatment of wastes and soils affected by heavy metals and high-molecular-weight organic compounds. Metals are typically immobilized by both chemical bonding and physical entrapment; organic compounds are immobilized only by entrapment. Fixation is a proven technology for immobilization of a variety of constituents, and is not difficult to implement on-site or off-site. This technology is therefore retained for possible use, if required to meet regulatory requirements for treatment prior to off-site disposal.

**Biological Treatment.** Biological treatment is a class of technologies commonly applied for destruction of organic constituents of concern. Biological treatment can be performed ex-situ and in-situ, with varying effectiveness, and may be accomplished by aerobic oxidation or anaerobic reduction processes. Biological treatment technologies for soils generally fall into two classes: land treatment or soil piles, and aqueous biotreatment of slurries in tanks or ponds. Biological treatment can have high effectiveness for some constituents, such as petroleum hydrocarbons, and poor effectiveness for many others, such as PCBs and other chlorinated organic compounds. Biological treatment will not destroy metals or remove them from soil. It is usually not suitable for solids wastes with high concentrations of constituents of concern. The difficulty of implementation can vary widely, depending on the matrix and the constituents of concern. When effective, biological treatment is usually inexpensive relatively to other organic destruction technologies. Because of its limitations, and the uncertainties in treatment needs at this site, biological treatment technologies are not retained.

**Chemical Oxidation/Reduction.** Chemical oxidation-reduction reactions can be used to reduce toxicity or to transform a substance to one more easily handled. Oxidizing or reducing reagents (as appropriate) are added to cause or promote the desired reaction. For example, oxidizing agents can be used to destroy or detoxify organic compounds. However, chemical oxidation/reduction of solid waste or affected soil is unproven technology that would be expensive because it would require the addition of relatively large quantities of reagent. Other effective and less costly technologies are available for removal of organic compounds. This technology is therefore not retained.

**Thermal Treatment.** Thermal treatment technologies are primarily designed for destruction of organic constituents of concern. Incineration is the most common thermal treatment technology, of which there are a number of processes with varying strengths and weakness. Thermal desorption is another thermal treatment technology which can remove and recover constituents of concern for subsequent incineration. Some thermal desorber designs operate at temperatures that provide organic compound destruction via thermal cracking (pyrolysis). Thermal treatment is required in lieu of or prior to land disposal of some wastes. It does not destroy or immobilize metals; thus the ash from incineration is often treated by fixation before landfill disposal. Volatile metals (e.g., mercury) may vaporize during thermal treatment, requiring special treatment of the offgas.

Thermal treatment is typically the most effective technology for destruction of organic compounds, with few limitations on the organic constituents of concern that can be treated successfully. It is the most complex and expensive organic treatment process. Thermal treatment would be used only if required by waste disposal regulations (i.e., RCRA land disposal restrictions).

On-site thermal treatment would be difficult to implement both from a technical standpoint, and also administratively due to air permitting requirements and resistance often encountered from the public. On-site thermal treatment is therefore not retained. Off-site thermal treatment is retained in the event it is necessary to meet waste disposal requirements for waste that might be encountered if the trench disposal area is excavated.

7.2.5.2 Groundwater

Groundwater at this site already meets remediation goals; therefore, there is no current need to treat the groundwater. In the event that groundwater became affected in the future (see Section 6.6), groundwater treatment technologies would be selected based on the constituents of concern identified at that time. Potential groundwater treatment technologies that would be considered are listed in Table 7-1. However, as there is no current need to treat groundwater and groundwater treatment is not expected to be required in the future, groundwater treatment technologies are not retained.

### 7.2.6 In-Situ Treatment

This section considers technologies that treat constituents of concern in place. As with ex-situ treatment, the purpose of in-situ treatment is to reduce the toxicity, mobility or volume of constituents of concern. The same classes of treatment that are available for ex-situ soil and groundwater treatment are generally available for in-situ treatment. However, the treatment conditions are very different. There are a number of in-situ treatment technologies that could be considered, were there an identified need. These include:

- Biological treatment (soil/groundwater)
- Chemical oxidation/reduction (soil/groundwater)
- In-situ fixation (e.g., grout injection or deep soil mixing)
- Soil flushing
- Vapor extraction (soil/groundwater)

When feasible, the key advantage to in-situ treatment is that excavation of the soil is avoided. However, the key disadvantage to in-situ treatment is that the treatment process cannot be controlled nearly as well as the same treatment in a reactor or other process equipment following excavation. This lesser control results from a combination of greater difficulties in achieving desired process conditions, and the inherent heterogeneity of the subsurface. Therefore, an in-situ treatment process is generally less effective at achieving treatment objectives and less reliable in achieving uniform treatment than the corresponding ex-situ treatment process. Treatment effectiveness is also often difficult to verify.

At this site, there is no identified need for treatment. Therefore, in-situ treatment would not be more protective than capping and there is no need for in-situ treatment. For this site, treatment would be better performed ex-situ, if required. Given the disadvantages to in-situ treatment and the lack of an identified need for such treatment, no in-situ treatment technologies are retained.

### 7.2.7 Disposal

Disposal is a general response action for final disposition of excavated waste and affected soil, or waste generated by treatment processes. Because no on-site treatment technologies have been retained, this discussion of disposal is limited to landfill disposal of excavated waste and affected soil.

Landfill disposal relocates constituents of concern from one place to another for long-term containment; it is not treatment to destroy or detoxify constituents of concern. However, if needed, treatment can be used prior to disposal. For example, sludge is commonly treated by fixation (chemical stabilization) prior to disposal. The options for disposal following excavation are an on-site constructed landfill, and off-site landfill disposal (including any treatment under land disposal regulations).

**On-Site Disposal (Constructed Landfill).** The near-surface bedrock and other subsurface conditions, described in Section 3.3, would make construction of a lined landfill difficult at this site. In addition, these same subsurface conditions provide limited natural containment. For example, as described in Section 3.6, there is general north-south channeling of groundwater in the area of the trench.

Infiltration through a properly designed landfill is controlled by the cap, not the liner. Because of the thickness of trench backfill, in-place containment would provide greater protection against direct contact. In-place containment would also avoid the many problems involved with excavating the trench (see Section 7.2.4.1). Capping with groundwater monitoring would provide sufficient protection of human health and the environment, would be much easier to implement, and would be much less expensive. Off-site disposal would be available in the event an excavation alternative were selected. On-site disposal in a constructed landfill is therefore not retained.

**Off-Site Disposal.** Commercial or municipal landfills could be used for disposal of waste or affected soil excavated from the trench. The appropriate landfill would depend on the nature of the material for disposal. For hazardous or dangerous waste, the nearest acceptable landfill would be the Chemical Waste Management facility in Arlington, Oregon. For other wastes, non-hazardous landfills could be considered. Municipal landfills are allowed to accept waste that is not classified as hazardous under federal (RCRA) regulations or as dangerous under Washington State regulations. Off-site disposal is retained for further consideration.

## 7.3 Assembly And Screening Of Remediation Alternatives

Remediation technologies retained following the screening process are assembled into remediation alternatives in this section. The technologies are combined to create a wide range of alternatives that represent various approaches to achieving remedial action objectives. The methodology for assembling alternatives is briefly discussed in Section 7.3.1. Each alternative is described in Section 7.3.2 in sufficient detail to distinguish primary strengths and weaknesses. Section 7.3 presents a screening evaluation of the assembled alternatives based on three general criteria: effectiveness, implementability, and cost. The purpose of the screening evaluation is to reduce the number of alternatives for detailed development and evaluation in Chapter 8. A summary of the retained alternatives is provided in Section 7.3.4.

### 7.3.1 Assembly Of Alternatives

Remediation alternatives are developed to meet the following MTCA requirements:

- Protect human health and the environment,
- Comply with cleanup standards,
- Comply with applicable laws and regulations,
- Provide for compliance monitoring,
- Use permanent solutions to the maximum extent practicable, and
- Provide for a reasonable restoration time frame.

Consideration of public concerns is performed by Ecology after the FS is completed and is based on public comments on the draft Cleanup Action Plan (CAP). Public concerns may result in modifications to the remedial action proposed in the draft CAP. Any modifications would be incorporated into the final CAP.

Clean up technologies are considered in the following order of descending preference per WAC 173-340-360(4):

1. Reuse or recycling;
2. Destruction or detoxification;
3. Separation or volume reduction;
4. Immobilization of hazardous substances;
5. On-site or off-site disposal at an engineered facility;
6. Isolation or containment with attendant engineering controls; and
7. Institutional controls and monitoring.

To meet these goals, a broad range of remediation alternatives is initially developed using the following strategies:

1. No action (baseline for comparison to other alternatives).
2. Limited action (e.g., institutional controls).
3. In-place containment of waste, affected soil, or affected groundwater without treatment, but still achieving protection of human health and the environment.
4. Excavation and disposal (containment), with or without treatment as appropriate.

### 7.3.2 Description Of Alternatives

The remediation alternatives for the Landsburg Mine site are summarized in Table 7-2 and described below.

**Alternative 1: No Action**

A "no action" alternative is included as a baseline for comparison to the other alternatives. This alternative would leave the site in its current state, assuming no restrictions on future site use, no site maintenance, and no monitoring.

**Alternative 2: Institutional Controls and Monitoring**

The purpose of this alternative would be to decrease site risks by preventing exposure to constituents of concern or resulting from waste disposal activities at the site. Long-term maintenance and monitoring would be included to ensure the continued effectiveness of the remedy.

To prevent site exposure, institutional controls would include deed restrictions, fencing, and warning signs. Fencing around the trench would provide a physical barrier against trespass. Warning signs would be placed on the fencing to discourage trespass. Stormwater run-on would continue to collect in the trench and infiltrate to groundwater through soil potentially containing constituents of concern. Periodic site inspections and maintenance of the fencing, signs, and any other physical components of the institutional controls would be included.

Groundwater use restrictions would be employed to prevent exposure to site groundwater. Thus, if site groundwater were to become affected by waste constituents, there would be no immediate exposure. Exposure could occur only following off-site migration. Routine, periodic monitoring would detect constituents of concern in groundwater were it to become affected.

Groundwater currently meets remediation goals. Therefore, no groundwater containment or treatment is currently necessary. In the event that groundwater were to become affected by waste constituents from the site, groundwater containment and/or treatment could be readily implemented. Alternate water supplies (e.g., bottled water) could be provided while appropriate action for groundwater cleanup were being implemented. Therefore, with this contingency available, institutional controls and monitoring addresses the possibility of future groundwater concerns.

**Alternative 3: Trench Backfill**

This alternative would protect human health and the environment by providing long-term containment of any waste and affected soil in the trench. This alternative would consist of backfilling the trench in the area where waste disposal occurred, combined with leveling and grading to provide proper stormwater drainage and prevent stormwater collection in the trench area. It would greatly decrease infiltration to groundwater by preventing stormwater run-on and collection. The backfill would provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The top layer of backfill would be 6 inches of vegetated soil to provide evapotranspiration and minimize erosion. Appropriate stormwater control measures would be included. Institutional controls and periodic maintenance and monitoring would be included as described for Alternative 2.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area, including a vegetated soil cover.
2. Grade and provide appropriate stormwater controls.
3. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

**Alternative 4: Soil Cap**

This alternative would protect human health and the environment by providing reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area (as in Alternative 3) and covered by a soil cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The soil cap would provide a thicker vegetated soil layer than Alternative 3 for improved evapotranspiration and long-term erosion control. The extent of the backfill and cap would be limited to the waste disposal area.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a clean soil cap over the trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

**Alternative 5: Low-Permeability Soil Cap**

This alternative would protect human health and the environment by providing proven, reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area and covered by a low-permeability soil cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The key difference between this alternative and Alternative 4 is the inclusion of a low-permeability soil liner in the cap. The liner would decrease the amount of infiltration through the cap, thus decreasing the potential for affecting groundwater. The cap would meet MFS (WAC 173-304). The extent of the backfill cap would be limited to the waste disposal area.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a low-permeability soil cap over trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

**Alternative 6: FML Cap**

This alternative would protect human health and the environment by providing proven, reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area and covered by a low-permeability FML cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The key difference between this alternative and Alternative 4 is the inclusion of a synthetic low-permeability liner in the cap. The liner would decrease the amount of infiltration through the cap, thus decreasing the potential for affecting groundwater. As a barrier to infiltration, a synthetic liner and 2 feet of low-permeability soil (as in Alternative 5) are approximately equivalent. However, synthetic liners are more susceptible to failure with settlement than soil liners. The cap would meet MFS (WAC 173-304). The extent of the backfill cap would be limited to the waste disposal area.

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a FML cap over the trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

**Alternative 7: FML/GCL Cap**

This alternative would protect human health and the environment by providing proven, reliable long-term containment of any waste and affected soil in the trench. The trench would be backfilled in the waste disposal area and covered by a low-permeability FML/GCL cap. This cover would prevent collection and infiltration of stormwater run-on, provide a thick barrier against direct contact with any waste or affected soil, and prevent off-site migration of constituents of concern in stormwater run-off or airborne dust. The key difference between this alternative and the preceding alternatives is the inclusion of 2 low-permeability liners. The cap would exceed MFS (WAC 173-304). Two liners do not provide lower infiltration than a single liner (provided it is properly designed, installed, and maintained), but provide additional reliability for long-term protection. However, synthetic liners are more susceptible to failure with settlement than soil liners. The extent of the backfill and cap would be limited to the waste disposal area.

The major steps in this alternative are:

1. Backfill the trench in the waste disposal area as required for capping.
2. Place a composite FML/GCL cap over the trench backfill, including appropriate stormwater controls.
3. Maintain the cap for 20 years.
4. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

**Alternative 8: Excavation and Off-Site Disposal of Surficial Affected Soil and Capping**

In this alternative, identified surficial soil within the trench containing concentrations of constituents of concern above remediation goals would be excavated and disposed off-site. However, protection of human health and the environment would be provided primarily by long-term containment of any waste and affected soil remaining in the trench. Following excavation of surficial affected trench soil, the trench would be backfilled and graded for proper stormwater drainage. Because waste and affected soil would presumably remain buried in the trench, a cap meeting MFS (WAC 173-304) would be placed over the trench (e.g., a low-permeability soil cap as in Alternative 5 or a FML cap as in Alternative 6). Groundwater protection is provided by the low-permeability liner included in the cap, which would minimize infiltration through residual waste and affected soil.

As discussed in Section 7.2.4.1, excavation creates risks for site workers and could result in exposure to or mobilization of constituents that are currently contained and immobile.

The major steps in this alternative are:

1. Excavate identified surficial affected soil in the trench and haul to an off-site commercial landfill for disposal.
2. Backfill the trench as required for capping.
3. Place a vegetated low-permeability cap (soil or FML) meeting MFS over backfill material, including appropriate stormwater controls.
4. Maintain the cap for 20 years.
5. Implement and maintain institutional controls and monitoring (as described for Alternative 2).

**Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected soil**

This alternative would provide long-term protection of human health and the environment by finding and removing all waste and affected soil from the trench for off-site disposal. The major steps in this alternative are:

1. Excavate the trench and remove all waste and affected soil.

2. Treat excavated material on-site or off-site as required to allow landfill disposal.
3. Haul waste and affected soil to off-site commercial landfill for disposal.

As discussed in Section 7.2.4.1, excavation creates risks for site workers and could result in exposure to or mobilization of constituents that are currently contained and immobile.

Appropriate disposal facilities would be used, depending on the waste designation (hazardous, dangerous, or non-hazardous). Treatment would be included in this alternative to the extent required to meet land disposal restrictions or other regulatory requirements. The need for treatment has not been established, and the type of any treatment cannot be determined at this time, due to the limited knowledge of specific constituents that would be encountered. Any required treatment would be performed either on-site or off-site, as determined appropriate at the time the need for treatment were identified.

Institutional controls, maintenance, and monitoring would not be necessary for this alternative because all waste and affected soil would be removed from the site.

### 7.3.3 Screening Of Alternatives

In this section, the remediation alternatives are screened to produce a refined list for detailed development and evaluation. The criteria for screening alternatives, as for technologies, are effectiveness, implementability and cost (see Section 7.2 for definitions). An alternative can be rejected because it is not sufficiently effective relative to another alternative or is not feasible to implement. An alternative can also be rejected by comparison to another alternative that is at least as effective for less cost, or is easier to implement for equivalent cost. An alternative can also be rejected in the case where the additional increase in effectiveness or implementability is not justified by the increased cost, provided the retained alternative is sufficiently protective of human health and the environment.

Alternative 3 (Trench Backfill) would fill the trench and provide proper stormwater drainage, which provides most of the protection in the other containment alternatives. However, Alternative 4 (Soil Cap) provides slightly more protection and reliability (due to a thicker vegetative soil layer) at nearly the same cost. Alternative 3 is therefore not retained.

Because waste and affected soil is presumed to remain buried in the trench, removal of a small quantity of surficial soil containing constituents of concern as provided in Alternative 8 (Excavation and Off-Site Disposal of Surficial Affected Soil and Capping) does not provide significant additional protection over the other containment alternatives. The identified affected soil in the trench is suitable for in-place containment. As with Alternatives 5 and 6, a low-permeability cap would still be included. Alternative 8 would remain primarily a containment alternative, but would be more difficult to implement and cost more, and is therefore not retained.

Alternative 9 (Excavation and Off-Site Disposal of All Waste and Affected Soil) would be very difficult to implement and by far the most costly alternative. Given the lack of constituents of concern in groundwater, the benefit (if any) is likely to be small. However, Alternative 9 is retained for detailed development and evaluation to allow comparison of the containment alternatives to an alternative that does not rely on on-site containment.

The remaining alternatives are protective of human health and the environmental, are implementable, and relatively cost-effective. These alternatives are therefore retained for detailed development and evaluation.

### 7.3.4 Summary Of Retained Alternatives

Based upon the screening of alternatives in the preceding section, the following alternatives are retained for detailed development and evaluation:

Alternative 1: No Action
Alternative 2: Institutional Controls and Monitoring
Alternative 4: Soil Cap
Alternative 5: Low-Permeability Soil Cap
Alternative 6: FML Cap
Alternative 7: FML/GCL Cap
Alternative 9: Excavation and Off-Site Disposal of All Waste and Affected Soil.

TABLE 7-1

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

| Technology | Screening Comments | Retained? (Yes/No) |
|---|---|---|
| **INSTITUTIONAL CONTROLS AND MONITORING** | | |
| Site Access Restrictions | | |
| Fencing | Effective, easy to implement, low cost | Yes |
| Warning signs | Effective, easy to implement, low cost | Yes |
| Security patrols | Expensive and unnecessary | No |
| Land Use Restrictions | Effective, easy to implement, cost uncertain (affects land value) | Yes |
| Groundwater use restrictions | Effective, easy to implement, low cost | Yes |
| Alternate water supply | Potentially feasible | Yes (contingency only) |
| Monitoring | Required component of site remedy | Yes |
| **CONTAINMENT** | | |
| Trench backfill | Necessary component of many alternatives (e.g., capping). Prevents direct contact with any waste and affected soil in the trench by a thick layer of clean fill, greatly enhancing the effectiveness and reliability of any containment remedy. Prevents off-site migration of constituents of concern in airborne dust or surface water; reduces the potential for affecting groundwater by eliminating current collection and infiltration of stormwater run-on. | Yes |
| Capping | Capping is proven, effective technology for providing reliable long-term containment and preventing or minimizing off-site migration of constituents of concern. | |
| Soil cap | Potentially effective; readily implemented; inexpensive | Yes |
| Pavement cap (asphalt/concrete) | Subject to cracking; inconsistent with expected land use; not as reliable as other cap options of comparable cost | No |
| Low-permeability soil cap | Effective and readily implemented | Yes |

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

| Technology | Screening Comments | Retained? (Yes/No) |
|---|---|---|
| FML cap | Effective and readily implemented; potential for failure in event of trench settlement | Yes |
| FML/GCL cap | Effective and readily implemented; potential for failure in event of trench settlement | Yes |
| RCRA Subtitle C cap | Other cap options provide sufficient protection for much less cost; potential for failure in event of trench settlement | No |
| Dust control | Potentially necessary during excavation or capping | Yes |
| Surface water controls<br>Grading<br>Stormwater drainage controls<br>Vegetative cover | Useful component of cap remedy | Yes |
| Vertical barriers<br>Slurry wall<br>Grout wall<br>Sheet pile wall<br>Cryogenic wall (freeze wall) | Hydraulic containment effective, more reliable, and more constructable at this site. | No |
| Horizontal barriers<br>Grout injection<br>Cryogenic barrier | Not feasible for site conditions | No |
| Hydraulic groundwater containment | Groundwater already meets remediation goals; therefore, no need for hydraulic containment. | No |
| **REMOVAL** | | |
| Excavation (soil/waste)<br>Backhoe<br>Loader<br>Bulldozer<br>Clamshell<br>Dragline | Excavation would be feasible, but much more difficult than normal and expensive. Worker health and safety would be a concern, and constituents of concern not currently exposed to the environment would become exposed. Excavation concerns include: (1) stability of the trench base, (2) stability of the trench sidewalls, (3) rupture of buried drums, (4) worker exposure, and (5) mobilization of constituents of concern. See text for discussion. | Yes |

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

| Technology | Screening Comments | Retained? (Yes/No) |
|---|---|---|
| Groundwater extraction<br>Extraction wells<br>Interceptor trenches | Groundwater already meets remediation goals; therefore, no need for groundwater extraction. | No |
| **EX-SITU SOIL TREATMENT** | | |
| Reuse/recycling | No waste materials identified with the potential for reuse or recycling; usually not feasible for complex mixtures of heterogeneous waste and affected soil | No |
| Dry sieving | Potentially effective; easy to implement; inexpensive means of reducing off-site disposal costs | Yes |
| Physical soil washing | May not be effective at this site; not established technology; difficult to implement due to the complexity and site constraints, unlikely to be cost-effective | No |
| Chemical extraction | Unproven; may not be effective at this site; difficult to implement; costly | No |
| Fixation (chemical stabilization) | Proven, effective treatment for metals and high-molecular-weight organic compounds; relatively easy to implement; moderate cost | Yes |
| Biological treatment | Not effective on many constituents of potential concern, such as chlorinated organic compounds and metals, therefore not suitable as general treatment for this site | No |
| Chemical oxidation/reduction | Unproven; may not be effective for site constituents of concern; other technologies are at least as effective and less costly | No |
| Thermal treatment<br>On-site<br>Off-site | On-site thermal treatment difficult to implement due to physical constraints and permitting difficulties; off-site retained in case needed to meet waste disposal requirements. | <br>No<br>Yes |

TABLE 7-1

SUMMARY OF TECHNOLOGY AND PROCESS OPTION SCREENING

| Technology | Screening Comments | Retained? (Yes/No) |
|---|---|---|
| **EX-SITU GROUNDWATER TREATMENT**<br>Gravity separation<br>Solids filtration<br>Sludge dewatering<br>Air stripping<br>Biological treatment<br>Carbon adsorption<br>Chemical oxidation/reduction<br>UV oxidation<br>Ion exchange<br>Precipitation<br>Reverse osmosis<br>Membrane filtration | Groundwater already meets remediation goals; therefore, groundwater treatment is not needed. | No |
| **IN-SITU TREATMENT**<br>Biological treatment<br>Chemical oxidation/reduction<br>In-situ fixation<br>Soil flushing<br>Vapor extraction | In-situ treatment technologies are inherently more difficult to control than the corresponding ex-situ treatment technologies. Treatment effectiveness is often difficult to verify. At this site, no need for treatment has been identified. Therefore, in-situ treatment would not be more protective than capping and there is no need for in-situ treatment. | No |
| **DISPOSAL** | | |
| On-site disposal (constructed landfill) | In-place containment (capping in combination with natural subsurface conditions) would provide sufficient protection; difficult to construct a lined landfill due to near-surface bedrock. | No |
| Off-site commercial landfill | Potentially feasible; expensive | Yes |

TABLE 7-2

SUMMARY OF REMEDIATION ALTERNATIVES AND SCREENING

| Alternative No. | Name | Description (Key Elements) | Retained? (Yes/No) |
|---|---|---|---|
| 1 | No Action | Current site conditions (no monitoring). | Yes |
| 2 | Institutional Contros and Monitoring | Deed restrictions; fencing and warning signs; periodic site inspection, maintenance, and monitoring. | Yes |
| 3 | Trench Backfill | 1. Backfill the trench and grade for proper stormwater drainage.<br>2. Cover backfill with a 6-inch layer of vegetated soil.<br>3. Implement and maintain institutional controls and monitoring. | No |
| 4 | Soil Cap | 1. Backfill the trench and grade as required for capping.<br>2. Place a clean soil cap over trench backfill, including appropriate stormwater controls.<br>3. Maintain the cap for 20 years.<br>4. Implement and maintain institutional controls and monitoring. | Yes |
| 5 | Low-Permeability Soil Cap | 1. Backfill the trench and grade as required for capping.<br>2. Place a low-permeability soil cap over trench backfill, including appropriate stormwater controls.<br>3. Maintain the cap for 20 years.<br>4. Implement and maintain institutional controls and monitoring. | Yes |
| 6 | FML Cap | 1. Backfill the trench and grade as required for capping.<br>2. Place a FML cap over trench backfill, including appropriate stormwater controls.<br>3. Maintain the cap for 20 years.<br>4. Implement and maintain institutional controls and monitoring. | Yes |
| 7 | FML/GCL Cap | 1. Backfill the trench and grade as required for capping.<br>2. Place a composite FML/GCL cap over trench backfill, including appropriate stormwater controls.<br>3. Maintain the cap for 20 years.<br>4. Implement and maintain institutional controls and monitoring. | Yes |

TABLE 7-2

SUMMARY OF REMEDIATION ALTERNATIVES AND SCREENING

| Alternative No. | Name | Description (Key Elements) | Retained? (Yes/No) |
|---|---|---|---|
| 8 | Excavation and Off-Site Disposal of Surficial Affected Soil and Capping | 1. Excavate identified surficial trench soil containing concentrations of constituents of concern exceeding remediation goals; haul to off-site commercial landfill for disposal.<br>2. Backfill the trench and grade as required for capping.<br>3. Place a vegetated clay or FML cap meeting minimum function standards over backfill material, including appropriate stormwater controls.<br>4. Maintain the cap for 20 years.<br>5. Implement and maintain institutional controls and monitoring. | No |
| 9 | Excavation and Off-Site Disposal of All Waste and Affected Soil | 1. Excavate the trench and remove all waste and affected soil containing concentrations of constituents of concern exceeding remediation goals.<br>2. Treat excavated material on-site or off-site as required to allow landfill disposal.<br>3. Haul excavated waste and affected soil to off-site commercial landfill for disposal. | Yes |